

THE USE OF TAMDAR AIRCRAFT WEATHER DATA IN CONVECTIVE FORECASTING

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1. INTRODUCTION

On the afternoon of 21 May 2005, a severe weather episode was forecast over the central Great Plains. The National Weather Service (NWS) forecast office in Sioux Falls, SD (FSD) used TAMDAR data to determine that the expected severe weather episode was unlikely to materialize in their area due to the presence of a strong capping inversion. TAMDAR sounding data from the late afternoon showed that the mid levels were much warmer than what the model forecast soundings indicated. This gave the office confidence to lower the probabilities of thunderstorms in their forecast area, and to coordinate with the Storm Prediction Center to leave some of their counties out of a convective watch.

On 7 June 2005 two separate convective episodes occurred across the western Great Lakes. Forecasters at the NWS forecast office in Green Bay, WI (GRB) monitored TAMDAR data over central and east-central Wisconsin and gained valuable insight into the evolution and strength of the cap during the day. During the morning, TAMDAR soundings downstream from an approaching MCS, revealed a rather dry air mass with a substantial cap in place over the forecast area such that any convection moving into the forecast area later in the day would likely remain elevated and weaken. Comparison of TAMDAR to RUC2 soundings indicated that the RUC2 had underestimated the strength of the cap early in the day. Later in the day, TAMDAR soundings also revealed the subsequent rapid erosion of the cap with severe convection exploding over the area ahead of a shortwave disturbance and associated surface trough.

This paper will examine how the routine monitoring of TAMDAR aircraft sounding data provided forecasters at both offices with valuable insight into the evolution and strength of the cap. These two cases will illustrate the need for real time sounding data and the danger in relying solely on model sounding data to assess convective potential.

2. THE TAMDAR EXPERIMENT

Despite the importance of upper air data to weather forecasts, meteorologists realize that the radiosonde and wind profiler networks are not likely to be expanded in the foreseeable future. In addition, the incremental forecast improvements based on increased computational speed and reduced model grid sizes will become less significant in the future unless additional upper air data is obtained (Douglas and Stensrud 1996). A new sensor system that shows promise to provide new upper air data in currently data-sparse areas will be discussed.

Tropospheric Airborne Meteorological Data Report (TAMDAR) is a joint project between NASA/FAA/NOAA and a private company called Airdat. As part of several aviation safety initiatives, NASA has contracted for the design and construction of an inexpensive instrument that can be placed on commuter aircraft that fly to medium and small cities that have little or no Aircraft Communication Addressing and Reporting System (ACARS) or Meteorological Data Collection and Reporting System (MDCRS) reports (Daniels et. al 2004). The data have filled in many of the data sparse areas in the United States and Canada. Areas in and around upper air sites that receive soundings twice a day have enjoyed increased spatial and

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temporal resolution in upper air data. This near Mesoscale sampling of the atmosphere has resulted in a better understanding of the near-storm environment and has led to improved weather forecasts and warnings.

The TAMDAR instruments are installed on 61 Mesaba Airlines Saab 340 turboprop aircraft. The aircraft fly routes that cover much of the Great Lakes and Midwest, as well as a significant portion of the Northeast and Southeast United States (Moninger et. al 2004). The TAMDAR data used in this study was obtained from NOAA's Forecast Systems Laboratory (FSL) interactive Java web page and the Advanced Weather Information and Processing System (AWIPS) via the Meteorological Assimilation Data Ingest System (MADIS).

3. SIOUX FALLS CASE

On 21 May 2005 a severe weather event was forecast across the Central Plains. The eastern Dakotas, western Minnesota, eastern Nebraska and western Iowa were forecast to be in the warm sector in the late afternoon as a surface low moved east towards Minnesota (Fig. 1). NAM Model forecast soundings from 1200 UTC, suggested a mid level cap (Fig. 2) would be overcome in the late afternoon by strong surface heating and mid-level cooling (Fig. 3). Forecast CAPE values of 2000 to 3000 Jkg^{-1} and favorable shear profiles (Fig. 3) suggested that the thunderstorms would likely be severe. The Storm Prediction Center (SPC) included this area in a slight risk for severe weather in their 1630 UTC convective outlook. By 1800 UTC visible

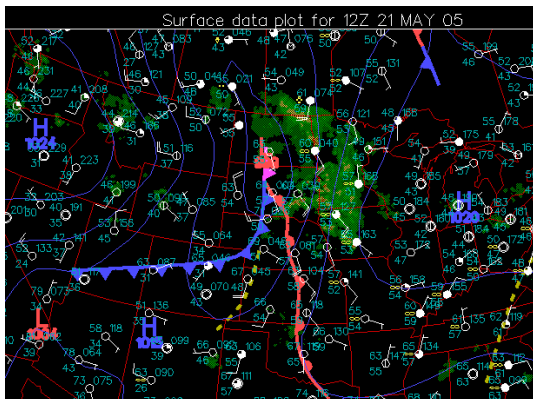


Figure 1. Surface map for 1200 UTC 21 May 2005 with analysis and radar data.

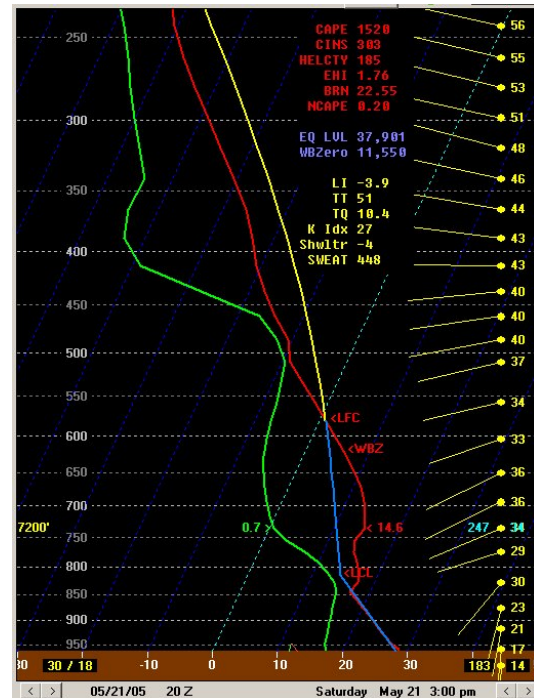


Figure 2. 1200 UTC 21 May 2005 NAM Model run BUFKIT sounding at Sioux City, IA at 2000 UTC 21 May 2005.

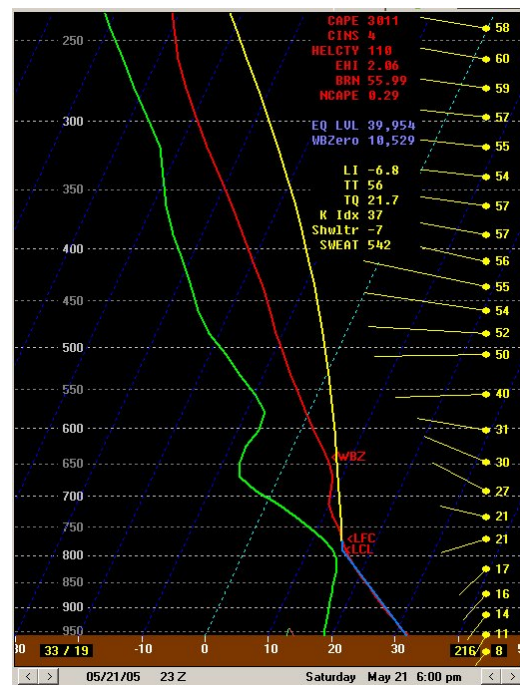


Figure 3. 1200 UTC NAM Model run BUFKIT sounding at Sioux City, IA at 2300 UTC 21 May 2005.

satellite imagery showed clear skies over western Iowa and the eastern Dakotas, except for some developing cumulus (Fig. 4). These cumulus were expected to develop into thunderstorms as the cap was broken.

FSD forecasters examined TAMDAR soundings from Sioux City, Iowa during the afternoon and early evening hours to assess the evolution of the cap. The soundings showed a mid level cap that would be nearly impossible to overcome by expected surface heating compared to the model forecast soundings (Fig. 5). Therefore, they lowered

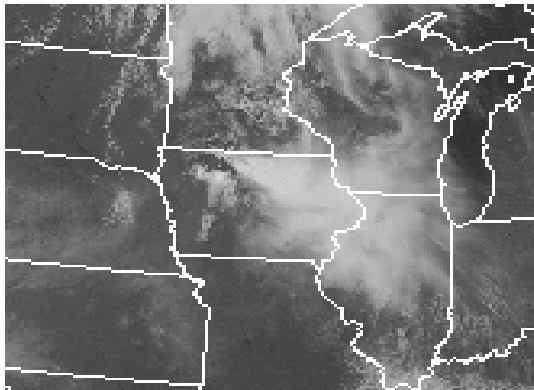


Figure 4. Satellite image at 1800 UTC 21 May 2005.

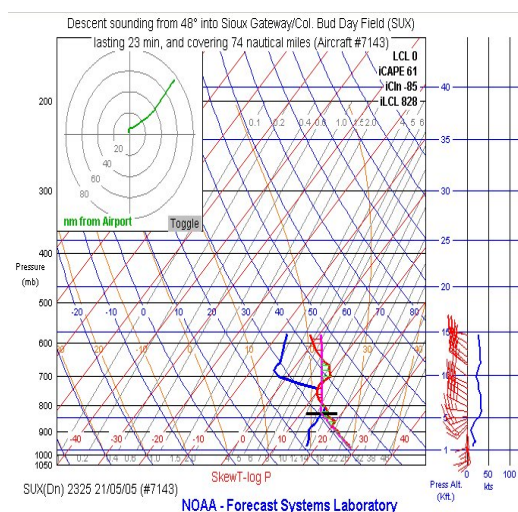


Figure 5. TAMDAR sounding for Sioux City, IA at 2325 UTC 21 May 2005.

the probability of thunderstorms in their local forecasts. At 2200 UTC Tornado Watch #311 was issued for the southern portion of FSD's forecast area (Fig. 6). Based upon the TAMDAR observations that the cap would be too strong to overcome, they coordinated with SPC to leave six of their counties out of the tornado watch. No severe weather was reported anywhere in the FSD forecast area that afternoon or evening (Fig. 7).

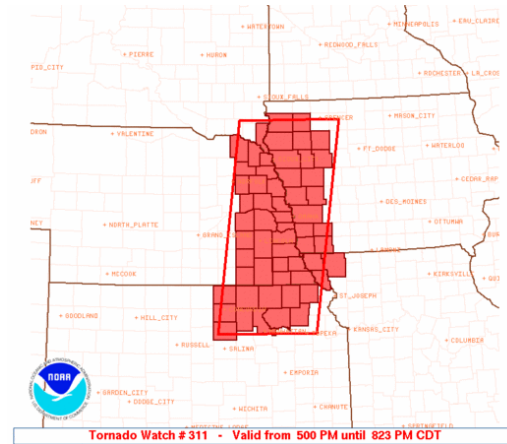


Figure 6. Tornado Watch # 311 for 2200 UTC 21 May 2005.

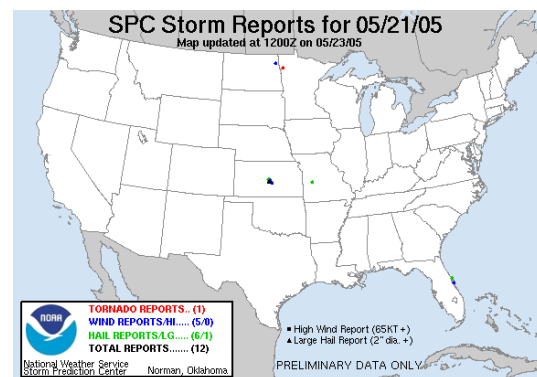


Figure 7. Preliminary storm reports for 21 May 2005.

4. GREEN BAY CASE

During the early morning of June 7, 2005, a weakening linear MCS was approaching the Green Bay (GRB) forecast area from eastern Minnesota. As the system pushed across southern Minnesota into far western Wisconsin, it produced some scattered wind

damage. By 1500 UTC, the MCS extended from near Eau Claire (EAU) to just west of LaCrosse, WI (LSE) with the convection primarily elevated in nature. Downstream of the approaching MCS, the atmosphere was destabilizing as temperatures climbed into the upper 70s to lower 80s over southwest into central Wisconsin with surface dew points in the mid to upper 60s (Fig. 8).

Severe Thunderstorm Watch # 425 was issued for parts of central and east-central Wisconsin from 1530 UTC to 2100 UTC (Fig. 9). RUC2 forecast soundings indicated that the cap would erode quickly with convection expected to become surface-based as it moved into central Wisconsin. However, examination of morning TAMDAR aircraft soundings at Mosinee (CWA) and Appleton (ATW)

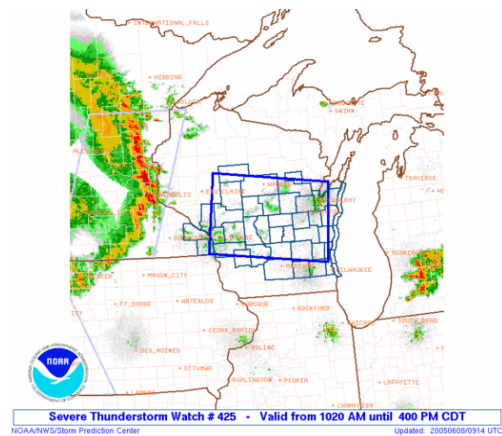


Figure 9. Severe Thunderstorm Watch #425 from 7 June 2005.

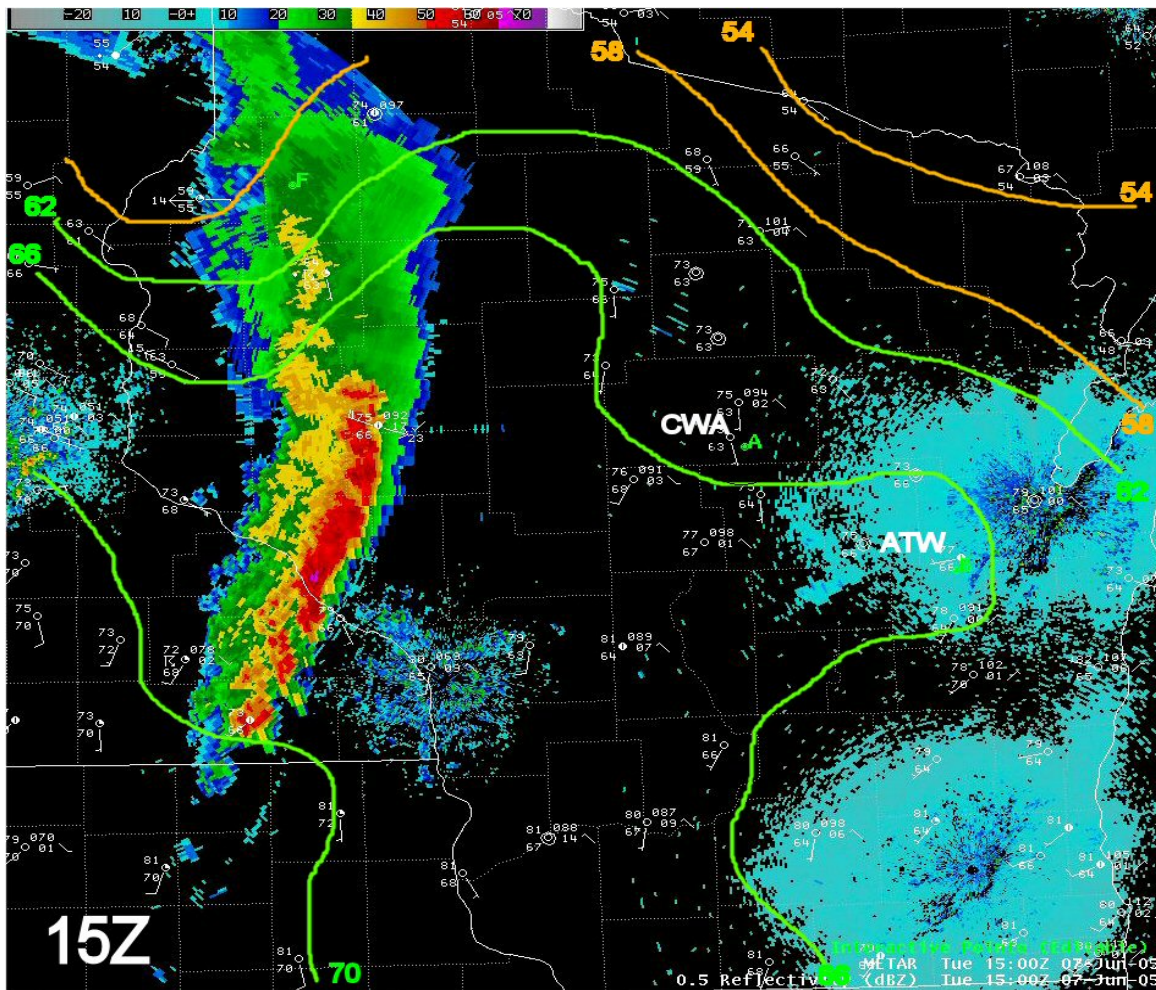


Figure 8. Radar and surface data for 1500 UTC 7 June 2005 with dew point contours.

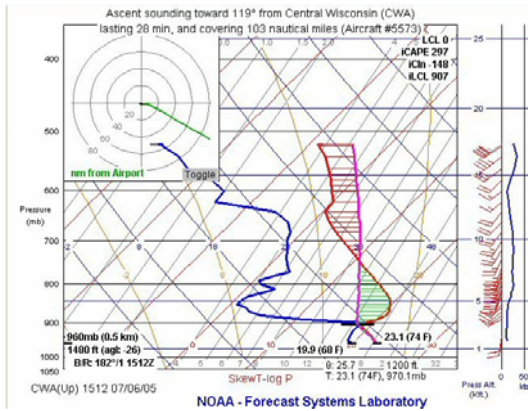


Figure 10. TAMDAR sounding for Mosinee, WI at 1512 UTC 7 June 2005.

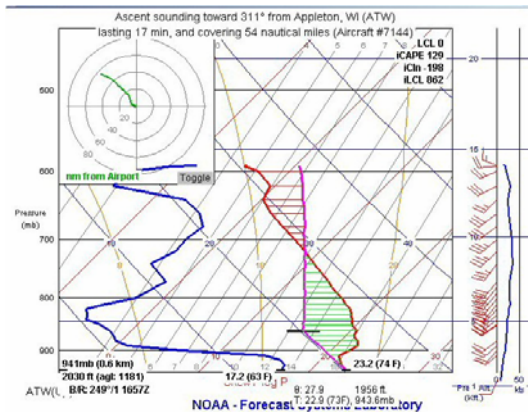


Figure 11. TAMDAR sounding for Appleton, WI at 1656 UTC 7 June 2005.

revealed a deep dry layer and impressive cap of 150 to 200 J kg^{-1} over the watch area (Figs. 10 and 11) that appeared to be stronger than what the RUC2 was forecasting, suggesting that the convection would likely remain elevated and weaken. In fact, the cap did remain strong through early afternoon and the convection gradually weakened with no severe weather reported in the GRB forecast area (Fig. 12). In the wake of the weakening convection, skies began to clear with surface dew points falling slightly over parts of central Wisconsin (Fig. 13). A comparison of the 1932 UTC CWA TAMDAR and 1900 UTC RUC2 sounding indicated the RUC2 had substantially underestimated the strength of the cap (Fig. 14).

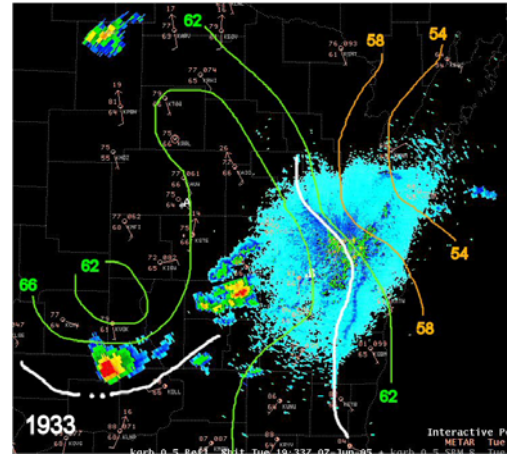


Figure 12. Radar and surface data for 1933 UTC 7 June 2005.

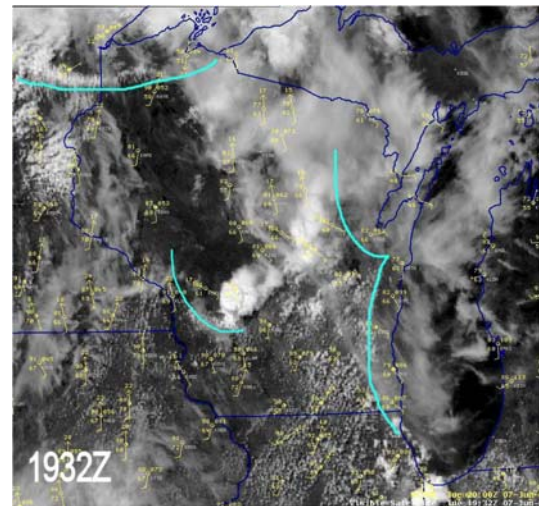


Figure 13. Visible satellite image for 1932 UTC 21 May 2005 with several boundaries outlined.

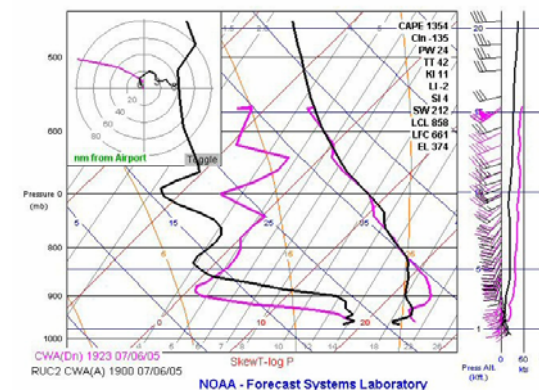


Figure 14. TAMDAR (pink) and RUC2 (black) sounding for Mosinee, WI at 1923 UTC 7 June 2005.

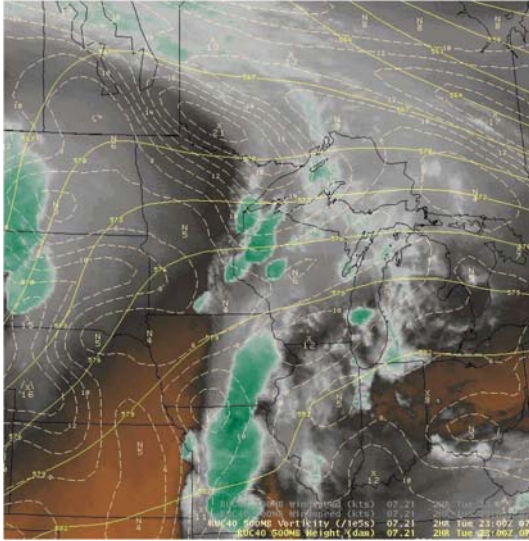


Figure 15. Water Vapor Image with RUC40 500 hPa height and vorticity for 2300 UTC 7 June 2005.

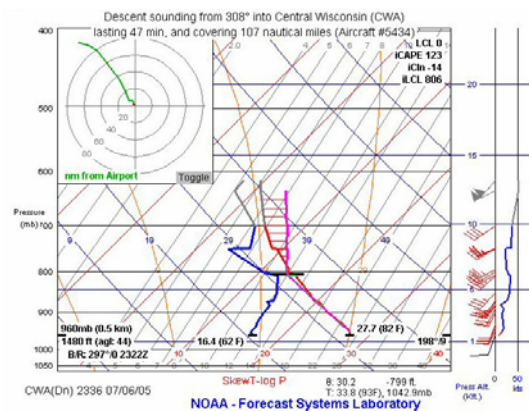


Figure 16. TAMDAR sounding for Mosinee, WI at 2336 UTC 7 June 2005.

Later on in the afternoon where skies had cleared over west-central Wisconsin, the atmosphere quickly destabilized ahead of a rather strong shortwave disturbance and associated surface trough approaching from Minnesota (Fig. 15). Examination of a subsequent CWA TAMDAR sounding indicated that the strong cap had rapidly eroded by 2336 UTC (Fig. 16) with severe convection exploding over parts of central and northwest Wisconsin (Fig. 17). SPC issued Tornado Watch #430 (Fig. 18) in response to the eroding cap later in the afternoon. Severe convection had also broken out over northern Wisconsin in the vicinity of a weak frontal boundary near the Wisconsin and Upper Michigan border.

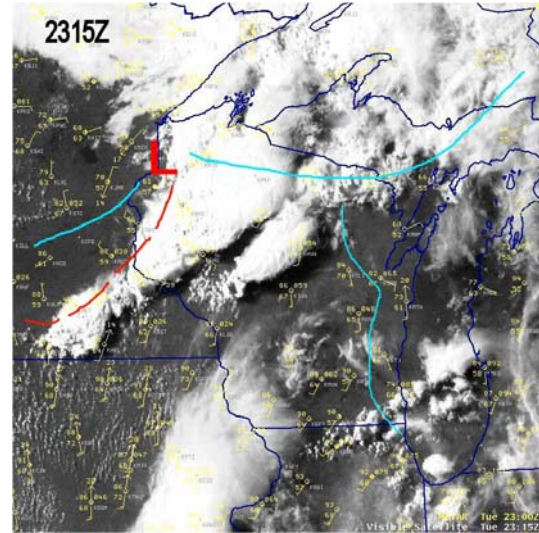


Figure 17. Satellite and Surface data for 2315 UTC 7 June 2005 with surface analysis.

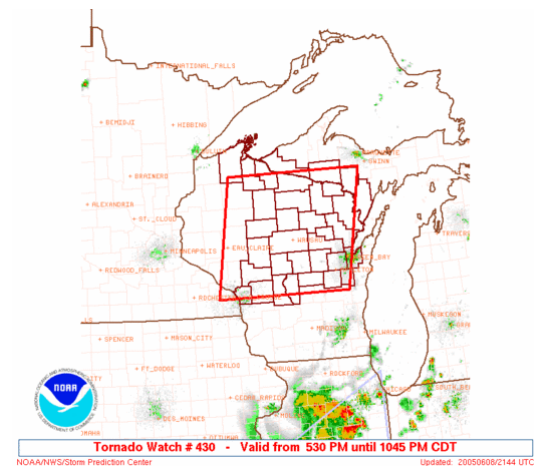


Figure 18. Tornado Watch #430 from 7 June 2005.

These storms became supercellular and generated impressive mesocyclones prompting the issuance of several Tornado Warnings. Surface data, radar data and visible satellite imagery hinted that a possible lake-induced boundary had pushed as far west as eastern Langlade and Forest counties helping to initiate the storms in that area (Fig. 17). These storms were probably the most impressive of the event in the GRB forecast area, generating baseball hail and substantial straight-line wind damage, however, no tornado touchdowns were ever confirmed. Examination of early evening CWA TAMDAR soundings (Fig. 16)

suggested that the LFC heights were rather high (5-6 kft) which may have inhibited tornado development over the forecast area suggesting that the TAMDAR soundings may have some utility in assessing LCL and LFC height with respect to tornado potential (Davies 2004).

5. SUMMARY

Until recently, forecasters had no real time way of assessing cap strength. TAMDAR and MDCRS data are now available, and can help meteorologists determine convective potential in real time. The routine monitoring of aircraft sounding data can provide forecasters with valuable insight into the evolution and strength of the cap (Mamrosh 1998).

On May 21, 2005, FSD and SPC meteorologists were able to improve their forecasts by leaving parts of South Dakota and Iowa out of the Tornado Watch. On June 7, 2005, GRB forecasters anticipated that convection moving into the forecast area during the late morning and early afternoon would likely remain elevated and weaken. Later in the day, TAMDAR soundings revealed the subsequent rapid erosion of the cap with severe convection exploding over the GRB forecast area ahead of a shortwave disturbance and associated surface trough. These two cases illustrate the danger in relying solely on model sounding data (Thompson and Edwards 2000) and the need for real time sounding data to assess short-term convective potential.

6. ACKNOWLEDGEMENTS

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